Molecularly Tunable Fluorescent Quantum Defects

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Defects can rule the properties of a crystal. This effect is particularly intriguing in atom-thick materials such as single-walled carbon nanotubes and graphene, where electrons, excitons, phonons, and spin may strongly couple at the defect sites due to reduced dimensionality. In this talk, I will discuss the chemical creation of molecularly tunable fluorescent quantum defects in semiconducting carbon nanotubes through covalently bonded surface functional groups that are themselves nonemitting. By varying the surface functional groups, the same carbon nanotube crystal can be chemically converted to create more than 40 distinct fluorescent nanostructures with unique near-infrared photoluminescence. This unexpected finding reveals intriguing roles of defects and opens up exciting possibilities for postsynthesis chemical engineering of carbon nanomaterials. Specific examples will be discussed to illustrate how defects may be used to brighten dark excitons, create selective chemical sensors, and harness silicon's potential for energy storage.